

Initial Project Description Report

Contract Number No.
W9132T-04-C-0012

Title
Proton Exchange Membrane (PEM) Fuel Cell Demonstration
Of Domestically Produced PEM Fuel Cells in Military Facilities

Submitted To:
US Army Corps of Engineers
Engineer Research and Development Center
Construction Engineering Research Laboratory
Broad Agency Announcement CERL-BAA-FY03

Submitted By
City of Mesa Utilities Gas Division
640 N. Mesa Dr.
Mesa, Arizona. 85211-1466

For Project Located At:
Arizona National Guard Armory
615 N. Center Street
Mesa, Arizona. 85201

April 8, 2004

Executive Summary

The City of Mesa Gas Division in partnership with the Arizona Army National Guard (AZARNG) is please to submit an initial project description report to the US Army Corps of Engineers Construction Engineering Research Lab (CERL). As part of the FY'03 PEM Demonstration Program managed by CERL, the City of Mesa is engaging in a progressive PEM fuel cell demonstration project for a period of one year with the option to extend the operation at the end of the one-year period.

For this project, the City of Mesa and AZARNG will purchase and install one residential fuel cell power plant, which will be tested and evaluated for performance at the Mesa Service Battalion Armory located adjacent to the Chicago Cubs training center at 615 N. Center Street, Mesa, Arizona. This building was selected due to the close proximity of the required support system needed for fuel cell use. Installation and commissioning of the fuel cell is expected to be completed by August of 2004.

The City of Mesa will have the responsibility to conduct all planning and site preparation for the Plug Power 5kW fuel cell. The City of Mesa along with AZARNG will also conduct all operations and maintenance functions and the decommissioning of the unit at the appropriate time. Plug Power will be responsible for providing the fuel cell and a one-year warranty along with any and all technical support necessary for fuel cell installation and operation.

The fuel cell will operate solely on natural gas in the grid parallel-connect mode. The thermal energy produced by the unit will be used to generate domestic hot water for the building use throughout the proposed one-year of operation. The total estimated energy savings of the fuel cell project are expected to be \$2,500.00 annually.

During the evaluation, Mr. Harry Jones, the Special Project Coordinator for the Gas Division will act as the host point of contact for the demonstration project. Mr. Jones can be reached at (480) 644-4496 or by email at Harry.Jones@cityofmesa.org.

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Proposal – Proton Exchange Membrane (PEM) Fuel Cell Demonstration of Domestically Produced Residential PEM Fuel Cells in Military Facilities

1.0 Descriptive Title

PEM Fuel Cell demonstration at Mesa Service Battalion Armory, Arizona Army National Guard, Mesa, Arizona

2.0 Name, Address and Related Company Information

City of Mesa Gas Division
640 N. Mesa Drive.
Mesa, Arizona. 85201
(480) 644-2137

DUNS# 02-014-1404
CAGE#
TIN# 86-6000-252

The City of Mesa is a municipal organization providing water, gas, and electric utility services.

3.0 Production Capability of the Manufacturer

Plug Power will provide one GenSys™ 5CS, 5kWe PEM fuel cell power plant for an operating or warranty period of one year from commissioning or 21,000 kWh, whichever occurs first. Plug Power will provide service agreements for extended operation beyond the one-year period at an additional cost.

Plug Power has been in design and production of PEM fuel cell systems since its inception in 1997. The GenSys™ is manufactured at Plug Power's Latham, New York manufacturing facility. The facility is a 50,000 square feet dedicated fuel cell production and test facility with approximately 100 employees. With current staff Plug Power production capability is five systems per week with the ability to significantly increase production.

4.0 Principal Investigator(s)

Gerald Paulus
Gas Division Director
City of Mesa
(480) 644-2872
(480) 644-3336
Gerald.Paulus@cityofmesa.org

Jeff Seaton
Energy Manager
Energy Engineering Specialist
Energy Manager
The Arizona Army National Guard
State of Arizona – DEMA
(602) 267-2743
jeff.seaton@az.ngb.army.mil

5.0 Authorized Negotiator(s)

Harry Jones
Special Projects Coordinator
City of Mesa
(480) 644-2137
(480) 644-5236
Harry.Jones@cityofmesa.org

6.0 Past Relevant Performance Information

Over a span of four years, the City of Mesa Gas Division and the Arizona National Guard has been involved in numerous successful distributed generation projects. The electrical production capability of these projects exceeds 628 kW. Over this time period, the Gas Division remains involved in the installation, maintenance, and repair of fuel cells.

Previous distributed generation projects include:

- The environmental office building located at the Arizona National Guard ECO Building, 5636 E. McDowell Road Phoenix, AZ. 58008-3495. This project site has evolved since 1997 and today is truly a self-sustained office structure, powered by twelve kilowatts of photovoltaic arrays and twelve hundred watts of wind turbines. Currently, six kilowatts of additional photovoltaic modules are being added to the ECO Building. Since 1997, Jeff Seaton has been involved in multiple distributed generation projects at this site. He is the Energy Engineering Specialist for Department of Emergency and Military Affairs (DEMA) Facilities Management with the Arizona Army National Guard. His contact number is (602) 267-2643.
- A 10kW, grid connected wind turbine at Camp Navajo Training Site in Bellemont, Arizona. Awarded in 2001, it is a \$70,000 distributed generation project made possible through a very successful partnership with the Army National Guard and the City of Mesa, Gas Division, and funding from DOD - National Guard Bureau. The point of contact for the project was Jeff Seaton, Energy Engineering Specialist for DEMA Facilities Management with the Arizona Army National Guard. His contact number is (602) 267-2643.
- The DG project, which installed two 200 kW fuel cells at the Western Army Aviation Training Site (WAATS) in Marana, Arizona. Awarded in 2000, the Gas Division was allotted \$200,000 for the purchase, installation, and operation of this fuel cell installation. Three, 200kW phosphoric acid fuel cells were relocated from previous DOD fuel cell projects. These three fuel cells were transported to the WAATS complex for installation. After salvaging parts and making repairs between the units, two units were installed at the Combat Mission Simulator Complex at the Western Army Aviation Training Site and supplied premium power for the critical operation of this facility. The City of Mesa operated these fuel cells for almost nine months. We received over 90,000 kWh of energy produced from the fuel cell installation. When the serving utility made arrangements to provide a secondary grid feed to the facility, the units were no longer needed and were retired. Together the City of Mesa, and the AZARNG gained great experience and benefited from the project. The point of contact for this project was Jeff Seaton, Energy Engineering Specialist for DEMA Facilities Management with the Arizona Army National Guard. His contact number is (602) 267-2643.

- The installation of a 200 kW fuel cell at the City of Mesa, which was installed at the Utility Operations building. Awarded in 1999, this \$800,000 project continues to provide electricity and thermal energy to the building during the day and electricity to the grid at night. The thermal energy is provided to the absorption chiller to cool the building and to provide domestic hot water. Thermal energy is also provided for heating for the building during winter months. This fuel cell has been operating successfully and efficiently for three years. For this project, the point of contact is Gerald Paulus, City of Mesa Gas Division Director. His contact number is (480) 644-2872.

The AZARNG and the City of Mesa have extensive experience in the field of distributed generation. In addition to the agencies individual track records, the agencies have successfully partnered on the installation and maintenance of fuel cells and wind turbine distributed generation projects in the past. These agencies are uniquely qualified to make this 5kW PEM Fuel Cell demonstration project a success for everyone.

7.0 Host Facility Information

The Mesa Service Battalion Armory is an Army post located adjacent to the Chicago Cubs winter training site just two miles north of downtown Mesa. This centrally located facility is currently home to the 1-180 Field Artillery (FA), a M109A5 howitzer battalion in direct support of the 11th Armored Cavalry Regiment. The City of Mesa is the provider of gas, electric, water, and wastewater utilities to the service.

Appendix 1 contains a picture of the facility.

8.0 Fuel Cell Site Information

The Mesa National Guard Armory is a main building used as an assembly area by the 1-180 Field Artillery unit. It has also on occasion served as a homeless shelter during the winter months. This building houses most of the necessary facilities used by personnel, which includes offices, locker rooms, and showering areas. The City of Mesa has identified the Mesa National Guard Armory located on the south side of the property as the desired location for this project. The fuel cell will be installed on the southwest side of the building, close to all of the building's utility connections.

The Mesa National Guard Armory is the preferred site location because of ease of connection with the building, the readily available utilities for fuel cell functions, and the close proximity to our Utility Department. Appendix 3 shows the general area where the fuel cell will be placed. This location puts the fuel cell within a 10ft radius of domestic water, electrical, and natural gas connections. Just beyond the wall of this proposed site are showers, restrooms and the mechanical room. The mechanical room is large enough to accommodate all fuel cell connections for both electrical, water conditioning, and plumbing needs.

The City of Mesa will locate a hot water heat exchanger, reverse osmosis equipment, circulating pump, and backflow valves in the mechanical room housing the hot water heater shown in Appendix 3. The automatic transfer switch will also be located in the mechanical room housing the Armory's hot water heater shown in Appendix 3. All piping and wiring will be run from the fuel cell in buried conduit to the building and through the building's restrooms. Natural gas will be supplied in buried pipe to the fuel cell from the gas meter shown in Appendix 3.

The GenSys™ 5CS 5kW fuel cell system, manufactured by Plug Power Inc. carries a CSA International certificate of safety. The applicable CSA certification is for outdoor operation in accordance with applicable codes and standards that govern the overall unit. The power conditioning system has a UL Listing. Tables 1 and 2 show the product specifications and compliance information. The fuel cell will also run in grid parallel and an interconnect agreement has been negotiated between the City of Mesa and the National Guard.

Table 1: Product Specifications

Attribute	Specifications												
Type of Fuel Cell	Proton Exchange Membrane (PEM)												
Model	GenSys™ 5CS												
Power Output	2.5 - 5 kW												
Manufacturer	Plug Power Inc., Latham, New York												
Unit Size	Base Unit with integral skid: 74"L x 32"W x 68 1/4"H												
Installation Location	Outdoor												
Grid Parallel	Yes												
Standby Capability	Maximum Load - 4.5kW, 400 hours per year of operation independent of the electric grid.												
Remote Monitoring Capability	Via phone line or RS232												
Output Voltage	120 VAC @ 60 Hz. Can be adapted to other standard voltages such as 240V or 480V.												
Certification	Integrated System CSA international Certified; Inverter UL Listed												
Waste Heat Utilization	Yes. System Efficiency will vary depending on external cogeneration loop temperature and flow rate. Based on the published overall system efficiencies of 60%, 65%, and 55%, the minimum thermal energy output of 3270W, 6400W, and 6700W should be expected for 2.5, 4, and 5KW setpoints respectively.												
Recovered Heat Output	<ul style="list-style-type: none">• Heat Recovery Liquid Operating Pressure Range 0 - 50 PSIG.• Heat Recovery Liquid Temperature Range 32°F to 130°F• Expected Heat Recovery Liquid Flow Range 0 to 10 GPM• Customer Fluid Connections to Fuel Cell<ul style="list-style-type: none">•3/4" NPT Female												
Electric Only Efficiency	26% @ 2.5 kW 25% @ 4.0 kW 23.5% @ 5kW												
Overall Efficiency (with CHP)	60% @ 2.5 kW 65% @ 4.0 kW 55% @ 5 kW												
Fuel Capability	Natural Gas												
Fuel Use	<p>Gas requirements are as follows: minimum of 70 standard liters per minute (SLM) of natural gas. Natural gas constituency must be >90% methane and sulfur content no greater than 15 ppm on a yearly average basis. Projected fuel consumption (MMBtus) at rated electric power, and electrical efficiency at peak and part-load conditions</p> <table><tr><th>Power (kW)</th><th>Efficiency (%)</th><th>Fuel use (BTUs/hour)</th></tr><tr><td>2.5</td><td>26</td><td>31,600 BTUs</td></tr><tr><td>4</td><td>25</td><td>54,600 BTUs</td></tr><tr><td>5</td><td>23.5</td><td>73,000 BTUs</td></tr></table> <p>Fresh water supply is required. System requires approximately 80 gpd, 136 gpd, and 176 gpd of fresh water at 2.5, 4, and 5 kW power levels, respectively.</p>	Power (kW)	Efficiency (%)	Fuel use (BTUs/hour)	2.5	26	31,600 BTUs	4	25	54,600 BTUs	5	23.5	73,000 BTUs
Power (kW)	Efficiency (%)	Fuel use (BTUs/hour)											
2.5	26	31,600 BTUs											
4	25	54,600 BTUs											
5	23.5	73,000 BTUs											

Table 2: Compliance to Applicable Codes and Standards

Code or Standard	Compliance
ANSI Z21.83, Standard for Fuel Cell Power Plants (fuel cell performance and safety)	The GenSys™ system has been evaluated and certified by CSA International to this standard.
NFPA 853, Installation Standard for Fuel Cell Power Plants >50 kW (fuel cells near buildings)	This standard is applicable to 50 kW and larger systems. It is not applicable to the GenSys™ system.
NFPA 70, National Electric Code (installation of electrical equipment)	The GenSys™ system will be installed in accordance with Article 692, Fuel Cell Systems, to be published in the 2002 National Electrical Code.
UL 1741, Inverters, Converters and Controllers for Use in Independent Power Systems & IEEE 1547, Standard for Interconnected Distributed Resources with Electric Power Systems	Power conversion equipment is UL Listed to this standard. IEEE 1547 - Draft standard is undergoing extensive revision by the 1547 Committee; the GenSys™ system complies with the technical requirements of the draft versions, and additionally, has been approved for interconnection under the New York State Standardized Interconnection Requirements, and the California "Rule 21" type testing requirements.

The GenSys™ 5CS, 5kW fuel cell system has the capability of providing electricity and allows for the recovery of waste heat for heating or domestic hot water use. Availability of waste heat is dependent on the production of electricity by the unit. The system will operate using natural gas as a fuel and in grid parallel mode to provide auxiliary on-site power and usable thermal energy to the facilities as needed.

Appendix 3 contains pictures of the mechanical room and gas meter location

9.0 Electrical System

The GenSys™ 5CS, 5kW fuel cell electrical system will utilize the existing building power panel to directly feed all available generated power to the site's electrical grid. The fuel cell will feed into this panel through a dedicated 50A single pole circuit breaker. All power generated by the fuel cell will be used by the facility.

The Mesa Service Battalion Armory does not have a generator backup in the event of a power outage. In the event of an outage, the fuel cell will not export power to the grid due to safety concerns. With this in mind, the fuel cell has been designed with a safety system to protect it in the event of grid failure.

Appendix 2 contains a picture of the electrical panel

10.0 Thermal Recovery System

The thermal recovery system is designed for continuous operation to supplement the present hot water heating system. The fuel cell thermal recovery feature will effectively provide supplementary thermal heat for hot water heating.

At full operation, the fuel cell thermal recovery system produces 30,000 BTUs @ 145 °F, this thermal recovery heat will be utilized on an as needed basis by the hot water heating system.

The system will use one fuel cell heating water through a heat exchanger in the Mesa National Guard Armory mechanical room. There will be a glycol loop on the fuel cell side, and a water loop on the hot water heater side of the heat exchanger. The fuel cell loop is connected to a common header loop filled with 50% propylene glycol allowing for year round operation. The units are piped back to the mechanical room and pumped through the primary side of the heat exchanger. The secondary side of the heat exchanger is piped into the inlet side of the existing hot water heater. Circulation pumps are included as necessary. The system will also include solenoids and a temperature stat to stop the circulation of the thermal recovery system in the event the building's hot water heater reaches a temperature where thermal recovery is not required. The fuel cell is also provided with a cooling assembly for heat rejection in the event the building cannot utilize the waste heat.

Appendix 3 contains pictures of the mechanical room and water supply.

11.0 Data Acquisition System

The fuel cell will have three systems of monitored control. Those systems are the System and Reformer Controller (SARC), Customer Interface Panel (CIP), and the SmartSignal predictive maintenance diagnostics technology. The fuel cell requires a dedicated phone line installed for monitoring and data gathering. The dial tone is carried to the fuel cell via a cat 5e twisted & shielded cable with an RJ11 jack to plug into the fuel cell. Routing of the cable is provided via a 1/2" nonmetallic liquid tight connection (D) located on the skid.

The System and Reformer Controller monitors for out of parameter conditions known as an E-stop as well as other abnormalities. An E-stop is considered any loss of communicate with critical systems necessary for the function of the fuel cell. Abnormal conditions are any system that is outside the range of normal fuel cell operation. If the SARC detects any E- Stop or abnormalities, it will immediately shut down the unit. Upon shutdown 15 minutes of data is stored and sent to Plug Power for analysis via the on board modem. E-mail is then generated and sent from Plug Power to the authorized service personnel.

The second system of monitor control is the Customer Interface Panel (CIP). The CIP will remotely monitor fuel cell status through a dedicated RJ11 cable connected to the fuel cell SARC system. CIP will allow monitoring of the fuel cell grid voltage, current, frequency and kilowatts along with the following; error codes, battery amps, battery voltage, battery temperature and system state.

The third system of monitor control is the SmartSignal predictive technology system. The predictive technology system will monitor the fuel cell operation and systems in real time to predict where trouble is developing in plenty of time to take corrective action. The goal of this technology is to avoiding costly shutdowns, outages, equipment failures, missed opportunities, or other costly emergencies. All information is provided in a Windows format with "drill down screens" designed to pinpoint potential problems or failing equipment within the fuel cell.

12.0 Economic Analysis

To analyze the potential performance of this technology demonstration, an analysis was run to determine the projected economic value of the project. To further the benefit of the unit, it will also utilize the hot water heat recovery system as a part of this project.

The analysis is design to reflect the actual operating criteria of the unit used for the project. The following data is used to determine energy & costs saving.

Example economic model:

Electric:

- Electric output = 2.5 kW
- Number of units = 1
- Operating hours = 7,008 hr/yr
- Electric costs = \$0.08/kWh

Gas:

- Gas input for Fuel cell = 31.6 CFH
- Gas Costs = \$6.30/MMBtu

Hot Water:

- Secondary (Load side) Flow = 5.4 gpm
- Water Temperature IN = 80 F
- Water Temperature OUT = 100 F

Savings Calculations:

- I. Electric Savings (\$/yr) = [(Electric output)*(No. of units)*(hr/yr)*(\$/kWh)]
= (2.5 kW)*(1)*(7,008 hr/yr)*(\$0.08/kWh)
= \$1,401/yr
- II. Gas Savings (\$/yr) = (500)*(gpm)*(no. of units)*(Tout – Tin)*(hr/yr)*(\$/MMBtu)
= (500)*(5.4)*(1)*(100 – 80)*(7,008)*(\$6.30/MMBtu)/10⁶
= \$2384/yr
- III. Gas Costs to Operate Fuel Cells = (CFH/unit)*(no. of units)*(hr/yr)*(1/1000 Btu/CF)*(\$/MMBtu)
= (31.6)*(1)*(7,008)*(1/1000)*(\$6.30/MMBtu)
= \$1,395/yr
- NET Savings (\$/yr)** = (Electric Savings) + (Gas Savings) – (Gas Costs to operate)
= (\$1,401/yr) + (\$2194/yr) – (\$1,240/yr)
= **\$2,393/yr**

13.0 Kickoff Meeting Information

The projected kickoff meeting date is set for June 2004. The following agenda is suggested discussed:

1. Job Schedule Overview
 - a. Engineering
 - b. Permitting
 - c. Site work
 - d. Fuel cell assembly and installation
 - e. Target completion date
2. Engineering
 - a. Preference of company
 - b. Suggested company
3. Construction
 - a. Civil
 - b. Mechanical
 - c. Electrical
 - d. SOC / Phone / Data
4. Site Information
 - a. Contacts
 - b. Security
5. Shut-downs
 - a. Notification
 - b. Procedures

14.0 Status/Timeline

1. Receipt of Fuel Cell
 - a. Delivery set for August 2004
 - b. Training set for August 2004
2. Permitting/Interconnection agreement set for July 2004
 - a. Sign interconnect agreement with the City of Mesa Electric
 - b. Acquire permits for installation if needed
3. Projected Construction start date is set for August 2004
 - a. Construction of support and electric systems for fuel cell operation
4. Projected Fuel Cell Start date is set for September 2004
 - a. Dedication and startup of fuel cell
5. Mid point Evaluation Report in March 2005
6. Final Report in September 2005

Appendix 1



Arizona National Guard Armory

Appendix 2



Proposed electric
connection from fuel
cell.

Propose entry point
for thermal recovery
and water supply for
fuel cell.



Appendix 3

